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Use of overbank sediments as a sampling medium in geochemical mapping

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RAPPORT

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Sammendrag:

An excursion was arranged in Norway 10.-14. September 1987 in order to study the use of overbank sediments as a sampling medium in geochemical mapping.

The conclusions of the excursion are:

Overbank sediments (o.s.) are composite samples that represent large drainage areas and can be collected at widely scattered sample sites at low cost. O.s. are transported physically in water suspension and are less influenced by chemical processes than stream sediments, which may have coatings of secondary minerals. O.s. collected at shallow depths may reflect anthropogenic pollution, while o.s. taken at depth may reflect natural conditions. Sampling and analysis of overbank sediments have been successfully applied in Norway and we recommend that an excursion is arranged in France and Western Germany in order to evaluate their use in geochemical mapping in other areas of Western Europe.

Emneord	Geokjemi	Kartlegging	
	Fagrapport	Vesteuropa	
	Flomsedimenter		

WESTERN EUROPEAN GEOLOGICAL SURVEYS

WORKING GROUP ON REGIONAL GEOCHEMICAL MAPPING

USE OF OVERBANK SEDIMENTS AS A SAMPLING MEDIUM IN GEOCHEMICAL MAPPING

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INTRODUCTION AND SUMMARY

An excursion was arranged in Norway 10.-14. September 1987 in order to study the use of overbank sediments as a sampling medium in geochemical mapping.

The participants of the excursion were the representatives in the Working Group from France (I. Salpeteur), Germany (R. Hindel) and Norway (B. Bølviken, with colleagues R.T. Ottesen and T. Volden). Individuals from GTK, Finland (P. Lestinen) and SGU, Sweden (S.Å. Ohlsson), took part due to the preparation of the Midtnorden Project. Jim Bogen of the Norwegian Water Resources and Energy Administration, was invited as a specialist in river erosion and sediment transport.

The conclusion of the excursion is that overbank sediments (o.s.) are an interesting sampling medium in large scale geochemical mapping owing to :

- O.s. are composite samples that represent large drainage areas, and can, therefore, be collected at widely scattered sample sites and at low costs to each country.
- O.s. are transported physically in water suspension and are less influenced by chemical processes than stream sediments, which may have coatings of secondary minerals. The interpretation of the dispersion patterns of element contents in o.s. may therefore be relatively simple.
- At a given sample site the age of o.s. increases with depth. By sampling at shallow depths the effects of anthropogenic pollution may be traced. Samples taken at greater depths may reflect the natural conditions that existed before the times of industrial pollution.

Overbank sediments have been applied successfully in Norway, and we think that they are also applicable further south in Europe. An excursion should be arranged during spring 1988 in order to study the use of overbank sediments as a sampling medium in middle Europe. The Norwegian excursion will be repeated 1988 for those members of the Working Group that could not take part in the 1987 excursion.

The following account presents:

- A definition of overbank sediments.
- Some advantages of overbank sediments over active stream sediments.
- Experiences from the use of overbank sediments in Norway.
- An overview of the possible uses of overbank sediment data in Europe.
- Some research recommendations.
- Examples of the costs involved in nation wide sampling of overbank sediments.

DEFINITION OF OVERBANK SEDIMENTS

Overbank sediments are products of major floods of river systems. During such floods the water discharge exceeds the quantities that can pass through the ordinary river channel (bankful discharge). Material suspended in the water of a flooding river will be deposited on river plains at higher levels than the normal stream channel (Fig. 1A and B). Such deposits of overbank sediments may later be eroded by stream water (Fig. 2), or — which is most often the case — overlain by more recent overbank sediments deposited during later floods. In this way nearly horizontal strata of young sediments above older are formed. The thickness of the layers may vary from a few millimetres to several decimetres (Fig. 3).

A vertical section through overbank sediments shows the sedimentation history back in time. A composite sample of such a section will give an intergrated picture of the chemical and mineralogical conditions in the whole drainage basin over a long period of time.

SOME ADVANTAGES OF OVERBANK SEDIMENTS OVER TRADITIONAL ACTIVE STREAM SEDIMENTS

The term stream sediments normally means active sediments from the stream bed in current contact with stream water. This sampling medium is widely used in geochemical mapping but suffers, nevertheless, from several drawbacks of which the most important are:

(1) During normal discharge conditions of a river only one or a few sources of limited areas may be exposed to erosion (Figs. 4 and 5). The major parts of the stream will approach an equilibrium with its surroundings, which means that erosion and deposition in most places are at a minimum. Consequently, as far as clastical (mechanical) sediment transport is concerned, active stream sediments reflect only limited parts of the drainage area.

(2) Active stream sediments are in most cases subject only to a temporary deposition. Active stream sediments, therefore, reflect the normal flow conditions of a river during a relatively short time interval.

(3) Active stream sediments may or may not have coatings of hydrous oxides and other secondary minerals. Such coatings often contain relatively large amounts of elements that normally occur as traces. The coatings therefore, influence the bulk compotition of stream sediments to a varying degree depending on the environmental factors.

(4) Active stream sediments are susceptible to contamination by mine wastes and other products of human activities in the drainage area. Geochemical maps based on the analysis of active stream sediments are, therefore, of limited value in the prospecting for new ore deposits in industrialized or densely populated areas.

Overbank sediments are advantageous for several reasons:

(1) The sediment sources of a river system may change through time. During catastrophic floods a number of sediment sources are opened up. A section of overbank sediments thus reflects large parts of a drainage basin.

(2) Overbank sediments do not have coatings of secondary minerals to the came degree as active stream sediments do.

(3) Since younger overbank sediments are deposited on top of older ones, overbank sediments of various ages can be sampled. By sampling the upper layers, the effects of anthropogenic pollution may be detected. By sampling lower layers pre-industrial natural dispersion patterns may be disclosed. Geochemical maps based on overbank sediments might therefore be very useful for the exploration of mineral deposits in populated areas.

EXPERIENCES FROM USING OVERBANK SEDIMENTS IN NORWAY

690 overbank sediments have been collected from 60-300 km^2 large drainage areas uniformly scattered all over Norway. The samples were sieved to minus 0.062 mm grain size and analysed for the acid soluble and total contents of a number of elements.

Map presentation of the analytical results show (see examples in Figs. 6 and 7).

- All elements included several of economic interest, depict large scale regional patterns.
- The patterns sometimes agree with known geological structures; in other cases they indicate features not known before.
- Different elements produce different patterns.

Visual interpretation indicate that the obtained geochemical dispersion patterns mainly reflect compositional differences in the bedrock. However, natural transportation of matter through air or water may also contribute

to the obtained patterns. The effects of anthropogenic pollution on the dispersion patterns are thought to be small.

POSSIBLE USES OF OVERBANK SEDIMENT DATA FROM WESTERN EUROPE

Overbank sediments can be used as an aid in:

- Exploration
- Geological mapping
- Environmental research
- Geomedicine (Environmental health)
- Agriculture
- Areal planning
- Other fields

Exploration: Relatively few samples of overbank sediments are needed in order to find the main geochemical distribution patterns of a country. It will therefore, be feasible to analyse the sample collections for many more elements than usual in geochemical surveys. In this way geochemical provinces of rare elements (f.ex. Au or Pt) may be disclosed. Since o.s. may represent conditions prior to excessive human activities, the original natural geochemical patterns may be detected even in mining or otherwise industrialized areas.

Geological mapping: Experience has shown that overbank sediments may disclose provinces and structures that point to new approaches in the interpretation of the regional geology. The patterns may be so large that they are recognizable only through geochemical mapping in areas larger than countries.

Environmental research: Dispersion patterns of the element contents in o.s. can reflect natural conditions as well as effects of pollution. Both are fundamental in environmental research. Geochemical mapping of Western Europe will aquire various data of value for the investigation of the effects of acid rain and other pollutants for example maps showing the distribution of sulphur, lead and susceptibility to acidification (Fig. 8).

Geomedicine (Environmental geochemistry and health): The occurrence of a number of diseases, amongst them dental caries, fluorosis and goiter, are related to the natural environment. Common diseases such as heart diseases and cancer, are thought to be effects of the environment. Nationwide and international geochemical data are important in the research relating

diseases and environment.

Agriculture: Geochemical maps show the distribution of elements of which some may be essential and others harmful for plants and animals. Regional geochemical maps can therefore, be used in the planning of food production as well as in forestry.

Areal planning: Regional geochemical maps can for example, provide data indicating which areas are suitable or not suitable for drinking water sources, waste disposal, mining, agriculture, recreation etc. from a geochemical point of view.

Other uses: Preparation of a joint geochemical map of Western Europe will promote the intersurvey cooperation and improve the art of applied geochemistry. The existing national geochemical data sets in Western Europe have been obtained by different techniques in each country, and cannot be compared. A consistent new set of geochemical data is important both scientifically and practically, and will throw light upon problems such as:

- Which are the main geochemical provinces in Western Europe?
- How do glaciation and various types of weathering affect the surface geochemistry?
- How important is airborne transportation from marine, volcanic and other sources as natural geological processes?
- The experience gained during the preparation of a geochemical atlas of Europe can prove to be of great value for similar investigations in developing countries. In these countries the geology is often poorly known and the infrastructure does not permit the dense sampling necessary for a geochemical survey based on stream sediments. This situation can be partially counteracted by taking overbank sediments; in this case one sample/100 km^2 - 500 km^2 is adequate.
- Would it be feasible to produce a Geochemical Atlas of the World?

CONCLUSIONS AND SOME RECOMMENDATIONS FOR RESEARCH

- We consider overbank sediments as a very interesting sampling medium in geochemical mapping and recommend that their application in Europe is further evaluated in an excursion in France and Western Germany during spring/early summer 1988.

- The depth of the anthropogenically contaminated upper part of the overbank sediments should be studied in various parts of Western Europe.

- Since the environmental conditions vary significantly throughout Western Europe, local orientation surveys are desirable in order to study to which extent precipitation and fluctuating ground water levels may have caused post-depositional chemical alterations of the composition of overbank sediments at depth.

- It is desirable to check the availability of overbank sediments in mountainous areas with a strongly rejuvenated relief (France) and in the mediterranean zone, where the average rain fall remained low during the late Quaternary.

- In middle Europe the representativity of overbank sediments should be studied in areas of well differentiated lithologies as well as in known mineralized districts, where a high density geochemical coverage already exists.

- Possible use of overbank sediments as a sampling medium for preparation of maps of succeptibility to acidification should be studied.

EXAMPLES OF EXTIMATED COSTS 1987 OF NATIONWIDE SAMPLING OF OVERBANK SEDIMENTS

France

Area: 547 000 km^2
Number of sample stations: 1094
Number of man-months for sampling: 14
Currency: F.F.

Net salary of sampling crew		630 784
Overhead		86 010
Total salary of sampling crew	FF	716 800
Field allowances etc.	"	103 600
Transportation	"	246 400
Sample bags etc.	"	10 000
Total cost of sampling (including overhead)	"	1 076 800
Cost per sample station (including overhead)	"	984
Cost of sampling, without overhead		990 784
Cost per sample station, without overhead		906

Germany

Area: 249 000 km^2
Number of sample stations: 498
Number of man-months for sampling: 6 (4-5 samples per day)
Currency: D.M.

Net salary of sampling crew		
Overhead		
Total salary of sampling crew	DM	111 000
Field allowances etc.	"	20 000
Transportation	"	25 000
Sample bags etc.	"	1 000
Total cost of sampling (including overhead)	"	157 000
Cost per sample station (including overhead)		315

Norway

Area: 324 000 km^2

Number of sample stations: 690

Number of man- months for sampling: 6.4 (5 samples per day)

Currency: Norwegian kroner

Net salary of sampling crew	NOK	120 000
Overhead	"	200 000
Total salary of sampling crew	"	320 000
Field allowances etc.	"	192 000
Transportation	"	150 000
Sample bags etc.	"	5 000
Total cost of sampling (including overhead)	"	670 000
Cost per sample station (including overhead)	"	966
Cost of sampling, without overhead	"	470 000
Cost per sample station, without overhead	"	680

For a given method all samples should be analysed in random order in the same laboratory regardless of country of origin. The costs per element determined will be comparable to the costs of analysis normally experienced in geochemical mapping. It is suggested that the samples are analysed for a greater number of elements than normal. The total costs of analyses may therefore be considerable. However, several geological surveys can take part in sample preparation as well as analysis, and cash flow between the surveys is probably not necessary.

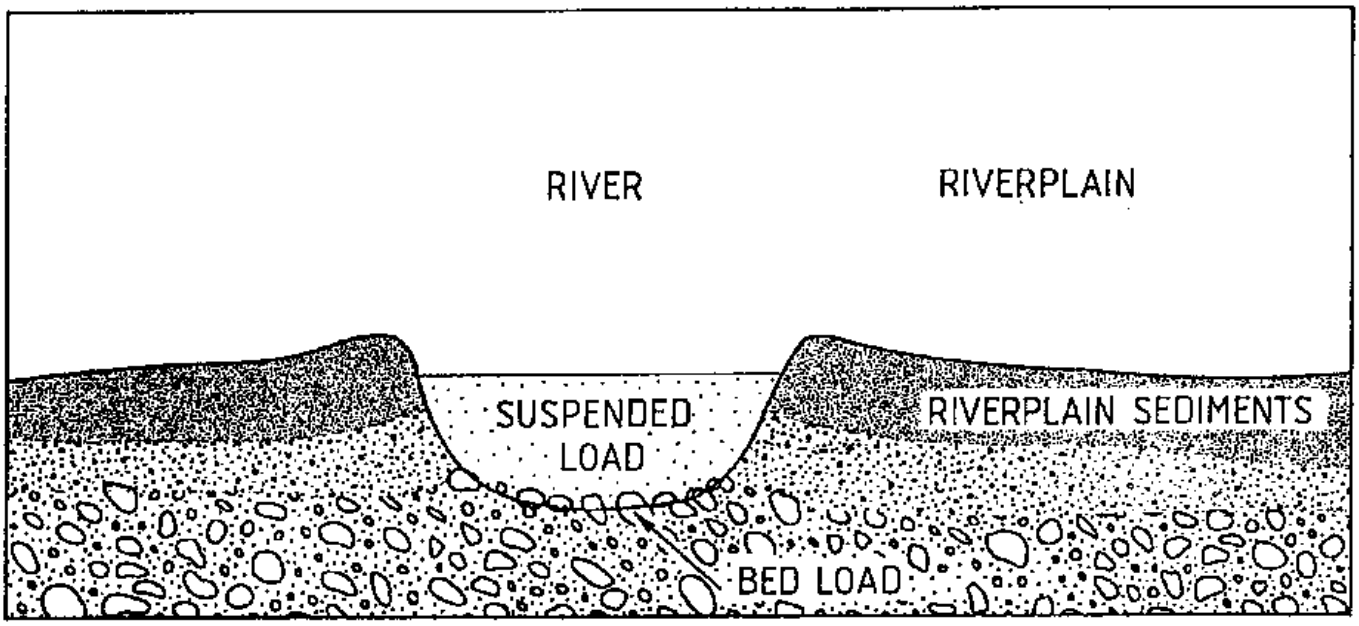

Fig. 1 Principle sketch of the water discharge of a river.

A. Water discharge of the river is less than bankfull discharge.

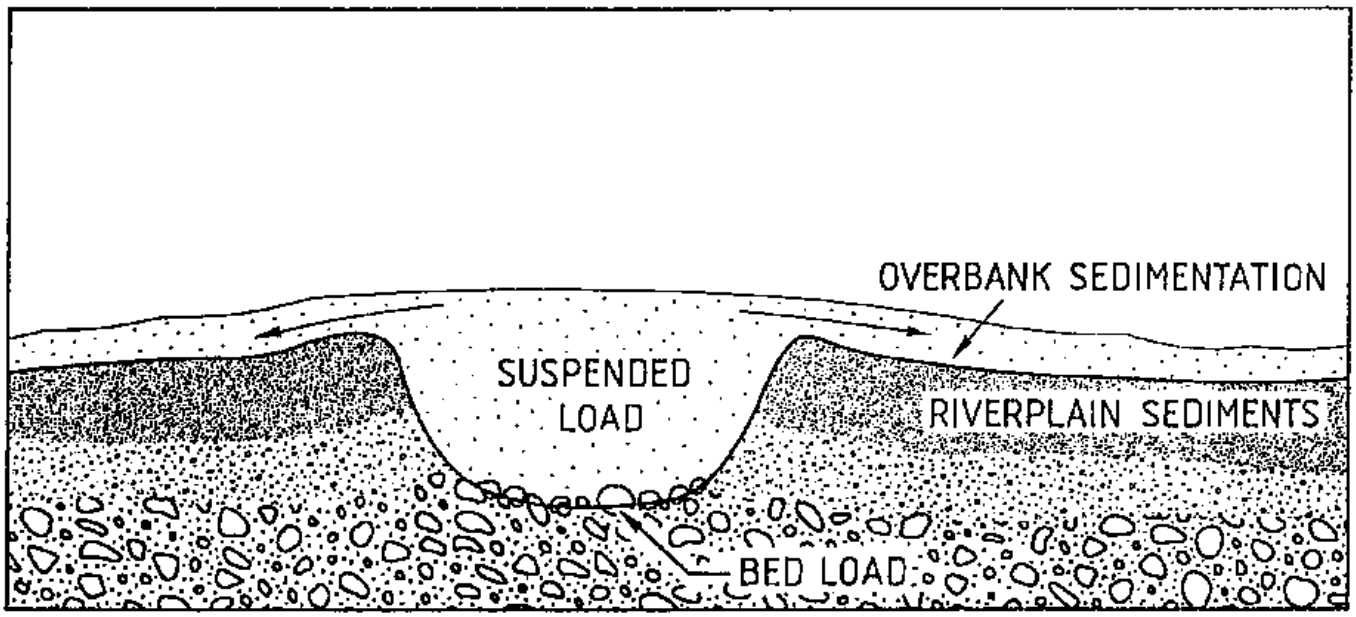

Fig. 1 Principle sketch of the water discharge of a river.

B. Water discharge of the river exceeding bankfull discharge during a large magnitude flood. Overbank sedimentation takes place on the riverplain.

Fig. 2. Overbank sediments being eroded by the river in Jostedalen, Norway.

Fig. 3. A section through overbank sediments, Atna, Norway.

Fig. 4. Erosion at apoint source of the river Lena, Southern Norway.

Fig. 5. Erosion at a point source of the river Karasjokka, Northern Norway. No erosion takes place of the bank at the far left side of the picture.

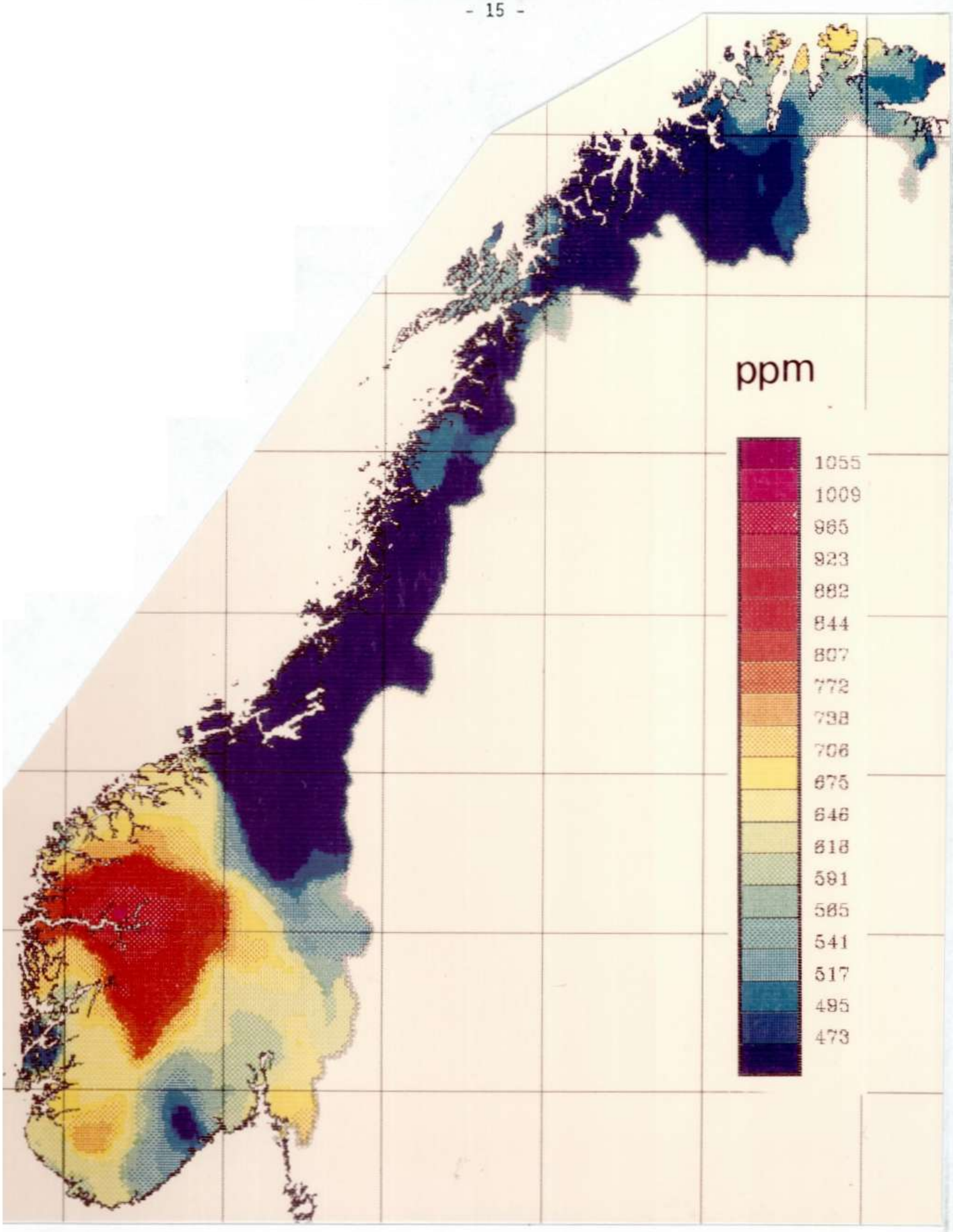

Fig. 6. Total barium in overbank sediments, Norway. The colours indicate the moving median (r=50 km) for 690 sample sites.

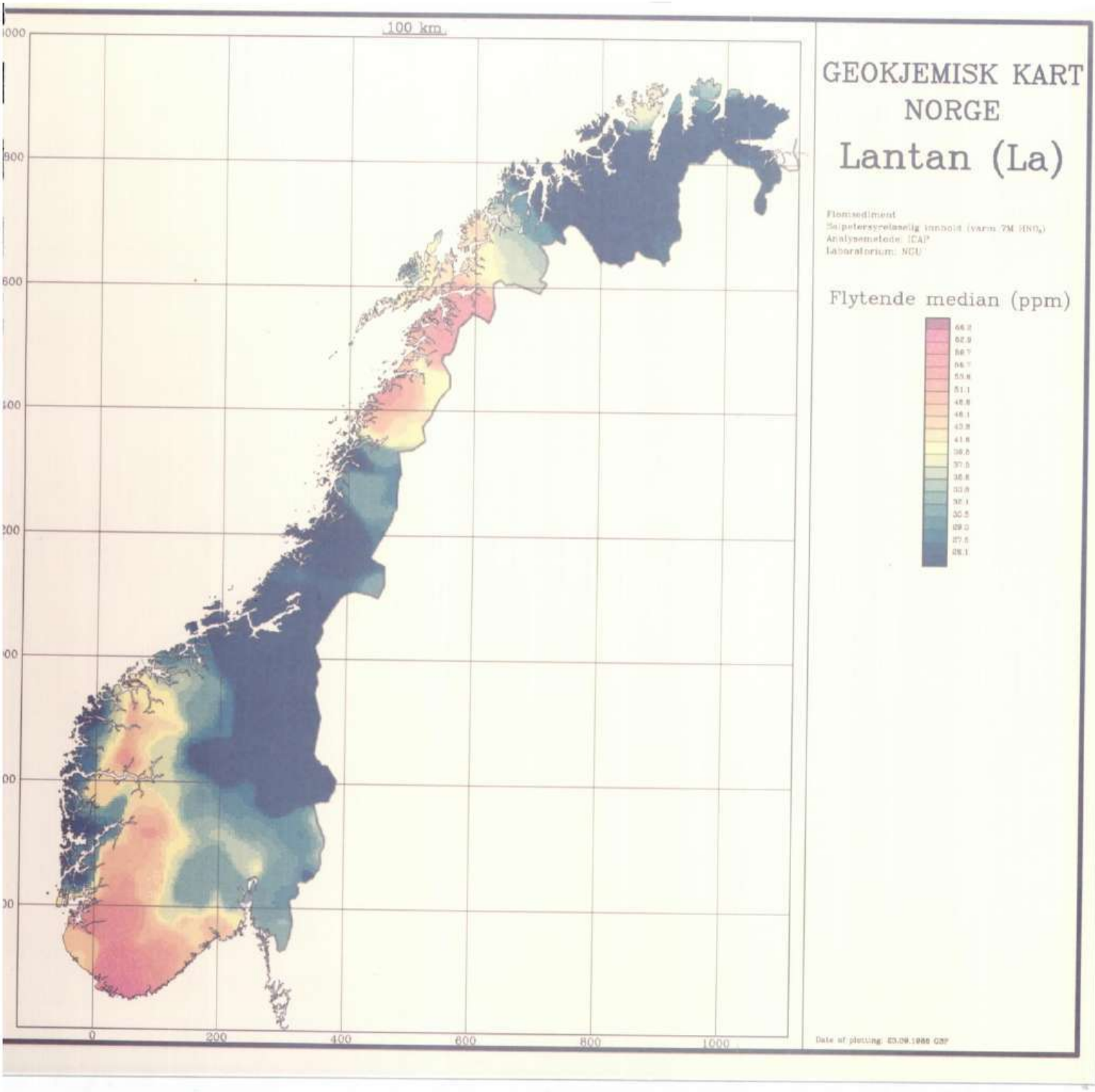

Fig. 7. Acid soluble lanthanum in overbank sediments, Norway. The colours indicate moving median (r=50 km) for 690 sample sites.

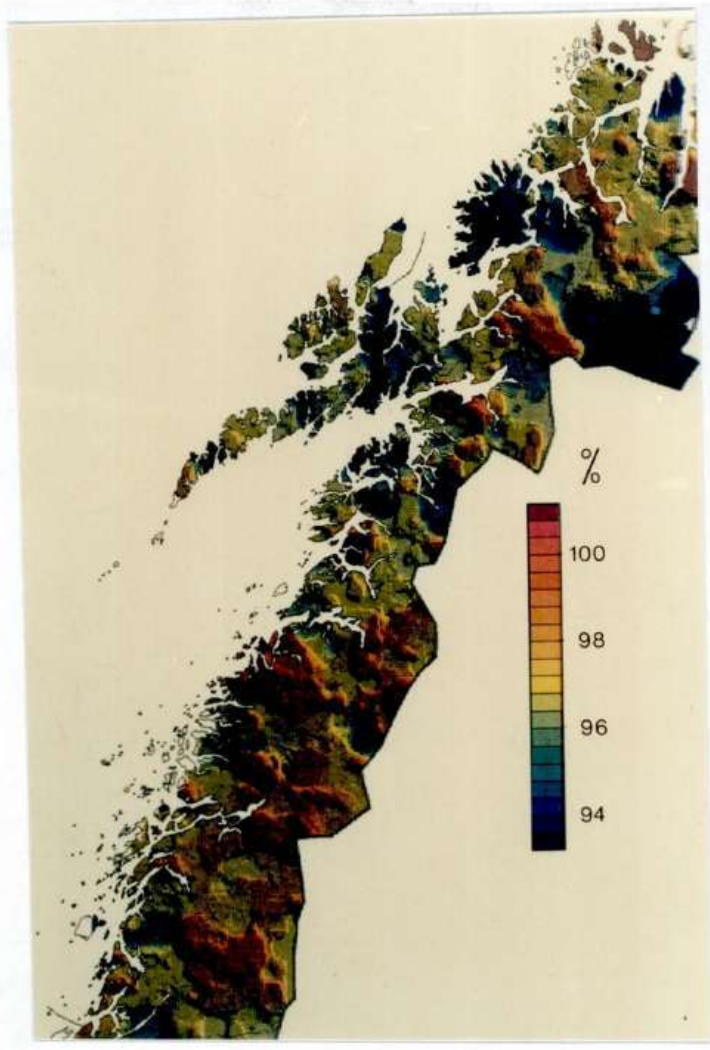

Fig. 8. Moving median (R=10 km) of the bufferpercent of the <0.06 mm fraction of 932 samples of till taken at a depth of 60 cm within the Nordland and Troms district, Northern Norway.

$$\text{Buffer percent (B)} = \frac{[H+]_A - \Delta[H+]}{[H+]_A} \cdot 100$$

Where $[H+]_A$ is the amount of hydrogen ions added normally as H_2SO_4 to a suspension of a soil sample.

Δ [H+] is the difference in concentration of hydrogen ions as recorded by pH measurements after (pH_2) and before (pH_1) addition of acid to a soil suspension.

In this case pH_1 was measured after 2g soil were shaken with 10 ml of water. pH_2 was measured after the addition of 10 ml 0.005 N H2SO4 to the water suspension.